

GEOLOGY OF BIBLIS PATERA, ULYSSES PATERA, AND JOVIS THOLUS,
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There are a variety of constructional volcanic features in Tharsis[1]. These features range from Olympus Mons and the Tharsis Montes shields, to the small low shields and fissure eruptions that characterize much of the volcanic plains, to the smaller volcanic constructs in the northeast and western parts of Tharsis. Here, I describe the geology of the western group, which includes Biblis Patera, Ulysses Patera, and Jovis Tholus. Each of these volcanoes has had a unique, and complex geologic history.

BIBLIS PATERA: Biblis Patera is located at 2.3°N, 123.8°. The volcano is elongate in a northwesterly direction and has a large, faulted caldera complex. The flanks of the volcano and adjacent plains are characterized by lava flows, northwest-trending graben and troughs, and caldera-concentric graben and troughs. Biblis Patera is 66 x 127 km with an oval 51 x 56 km caldera; the summit elevation is ~9 km, standing ~2 km above the surrounding plains [2]. The construct has an estimated volume of $8\text{--}22 \times 10^3 \text{ km}^3$.

The caldera is characterized by numerous fault blocks surrounding the margin and a complex central floor that lies ~2 km below the rim. Several major graben lie just outside the caldera rim and several major fault blocks are contained within the caldera rim; the caldera has clearly expanded (~12 km) due to fault blocks dropping into the interior. The central floor exhibits a smooth annular region surrounding an area of ridged plains and a pit crater. The flank is characterized by a variety of volcanic and tectonic features - lava flows, pit craters, graben, and troughs. Two groups of faults occur, a northwest trending group cutting across the plains and the volcano, and a second group concentric about the caldera. The concentric graben are older. The flanks exhibit a radial texture that is interpreted to represent a myriad of lava flows. Several broad aprons of lava flows also occur on the flank and appear to emanate from concentric fractures and channels. There are many similarities between the style of eruption exhibited by Biblis Patera and that of the Galapagos Islands shields [3].

ULYSSES PATERA: Ulysses Patera is located at 2.7°N, 121.3°W and stands -2-3 km above the surrounding plain [2]; flank slopes are -7° to 12°. The caldera floor is quite deep, lying 1.8 to 2.2 km below the caldera rim. The caldera has a void volume of $\sim 5000 \text{ km}^3$, the total solid mass volume of the volcano is $7\text{--}16 \times 10^3 \text{ km}^3$.

The flanks of Ulysses Patera are characterized by a clearly defined radial texture, two huge impact craters and minor faulting. Locally on the flanks, individual lava flows (800 m wide) can be recognized, elsewhere the surface texture indicates lava flows extending down the flank from a central source (overflow from a completely filled caldera or a more localized source that subsequently collapsed into the caldera). The flanks are cut by north-northwest trending graben of variable width and age. Two large impact craters (15-30 km) also occur on the flanks. On the caldera floor, 15 low hills are observed. Based on their morphology, circular outline, and the presence of a central pit, they are interpreted to be cinder cones. Individual cones range from 300- 1600 m in diameter; the summit craters are ~50 m in diameter; volumes are estimated to be $\sim 0.1 \text{ km}^3$. Two shallow depressions occur on the southwest floor of the caldera, they are a few km in diameter and have etched margins. These depressions are interpreted to be volcanic pit craters whose interiors were filled with molten lava. Crater counts indicate a paucity of craters <1000 m suggesting small diameter craters have been removed or buried. Aside from the relatively large caldera, Ulysses Patera appears to be a basaltic

shield. The presence of cinder cones on the floor suggest a limited amount of more highly evolved magma was erupted during the waning stages of volcanism.

JOVIS THOLUS: Jovis Tholus is centered at 18.3°N; 117.5°W; it is a low relief, volcano with gentle flank slopes of between 3 and 8°. The construct is dominated by a series of inset calderas which make up the largest fraction of the area. The caldera complex is offset to the southwest side. Total shield dimensions are --77 km (e-w) by 62 km (n-s); the caldera complex is 44 x 34 km. The shield is embayed on all sides by younger Amazonian age volcanics. Total relief, relative to the surrounding plains, is probably ~2 km [2]. The total volume of Jovis Tholus is estimated to be $\sim 2.5 \times 10^3 \text{ km}^3$.

At least five episodes of caldera formation have occurred on Jovis Tholus. Caldera formation apparently migrated across the construct to the southwest. The caldera margins are cut by faults and have scalloped edges suggesting the coalescence of many caldera. The caldera volumes appear to increase with time, the youngest caldera being the largest. Caldera diameters are a few to more than 20 km across and depths relative to other caldera range from a few tens of meters to several hundred meters. Superimposed across the youngest caldera complex, and presumably marking the youngest volcanic activity, is a low shield. The shield covers a significant fraction of the caldera floor, measuring 17 x 21 km; an irregular vent 2.7 km x 560 m marks the summit. The total volume of the small shield is $\sim 10^2 \text{ km}^3$. The flank of Jovis Tholus is rough and hummocky with a radial texture suggestive of flows just below the limit of resolution. Several troughs and pit chains, and graben cut the flanks of the volcano. The absence of small diameter craters on the flank of the volcano suggests that it has been resurfaced.

Crater counts for these volcanoes [4,5] indicate that Biblis Patera, Ulysses Patera, and Jovis Tholus are old in comparison to the large Tharsis shields, similar in age to the Elysium volcanoes, and younger than the patera of the southern highlands. As these volcanoes represent shield volcanism, as do the large Tharsis Montes shields, it suggests that a volcanic style in which low viscosity lavas were erupted from a point source to produce a volcanic construct was established during the earliest phases of geologic activity in Tharsis. The observation that Biblis Patera, Ulysses Patera, and Jovis Tholus, and the Uranus group to the northeast, are older than the Tharsis Montes shields, suggests that the style of volcanism changed with time. These early volcanoes were of small total volume and were probably built rapidly ($\sim 10^6 \text{ yrs}$). The source region was either cut off or rapidly depleted such that a large shield could not be built. The presence of the calderas suggests that significant magma chambers occurred in the near surface to allow collapse resulting in caldera formation. Despite the relatively large caldera size, it seems unlikely that these volcanoes are buried by more than a few hundred meters of lava around their flanks. Biblis Patera, Ulysses Patera, and Jovis Tholus all represent basaltic shield volcanoes.

References: [1] Greeley, R., and Spudis, P., 1981, Rev. Geophys. Space Phys., 19, 13. [2] U. S. Geological Survey, 1991, U. S. Geological Survey Miscellaneous Investigation Series Map I-2113. [3] Nordlie, B., 1973, Geol. Soc. Amer. Bull., 84, 2931. [4] Neukum, G., and Hiller, K., 1981, Martian ages, J. Geophys. Res., 86, 3097. [5] Plescia, J., and Saunders, R. S., 1979, Proc. Lunar Planet. Sci. Conf., 10th, 2841.